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ABSTRACT

An evaluation of the Mathematics and Computer Assisted Remedial Teaching (MASCART) project in the Pre-Entry Science Course (PESC) at the University of Botswana focused on two questions: (1) Considering the conditions for successful implementation highlighted in the literature, has the implementation of computers in the PESC department been such that institutionalization can be expected? and (2) Did the use of the MASCART software result in knowledge gains? A case study design was utilized for the first question and a pretest-posttest design for the second. Most of the factors influencing the success of implementation were fulfilled. Although the institutionalization phase is not yet complete, developments are promising. Based on the case study design, it can be concluded that there is no reason to doubt, for the time being, the validity of the theoretical starting point of the study--that the implementation and institutionalization of an educational change depend on the existence of specific conditions at the level of the materials themselves, the institution, and the society. With respect to the second question, a general improvement in basic algebra knowledge and skills was measured. While this gain cannot be unequivocally attributed to the quality of the MASCART materials, data indicate that the combination of increased time on task and working with MASCART materials was effective. (16 references) (Author/GL)

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THE EVALUATION OF REMEDIAL COMPUTER USE FOR MATHEMATICS WITHIN A UNIVERSITY SETTING IN BOTSWANA

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SUMMARY

This paper describes the evaluation of the Mathematics and Science Computer Assisted Remedial Teaching (MASCART) project in the Pre-Entry Science Course (PESC) at the University of Botswana. The evaluation focussed on the following questions:

- Considering the conditions for successful implementation as mentioned in the literature (e.g. Fullan, 1982), has the implementation of computers in the PESC Department been such, that we may expect institutionalization ?
- Did the use of the MASCART software by students indeed result in knowledge gains?

For the first question a case study design was applied, for the second one an experimental design. It could be concluded that most of the factors influencing the success of implementation were fulfilled, while some weak points could determined. Although the phase of institutionalization is not yet completed, developments are promising.

With respect to the second research question, a general improvement in basic algebra knowledge and skills could be measured. We could not proof that this improvement was caused by the quality of the MASCART materials, but the data show that the combination of increased time on task and the working with MASCART materials was effective.

Based on the case study design, it could be concluded that for the time being we have no reasons to doubt the validity of our theoretical starting points, that certain factors influence the implementation and institutionalization of an educational change.

1. INTRODUCTION

This paper describes the evaluation of the Mathematics and Science Computer Assisted Remedial Teaching (MASCART) project in the Pre-Entry Science Course (PESC) at the University of Botswana. Botswana has an educational system that is still developing towards a more definite shape. The secondary school (a typical product of the British leading role in the southern African region) takes five years and school leavers who wish to enter the Faculty of Science of the University of Botswana first has to take PESC . PESC is a remedial bridging course between secondary school and university, that lasts for about 7 months, covering topics from Mathematics, Chemistry, Physics, Biology and Language and Study skills. The training of basic conceptual ideas, cognitive and practical (laboratory) skills and methods in these subjects are considered to be more important than acquisition of pure facts. The number of students participating in the course is increasing every year since the start of the course in 1975. In January 1989, about 300 students entered the PESC course. When still in secondary school, students are selected for entering PESC by a PESC-lecturer team. This selection is based on students performance in the Cambridge Overseas School Certificate (COSC) or on PESC's own selection tests, and on a recommendation from the secondary school. The best students of a grade cohort are thus selected for following the PESC course.

A report on the use of computers in the University of Botswana in 1985 was a starting point for considering the introduction of computers in the department of PESC; assistance was provided by the Basic Science Program Unit (BSPU) of the Free University Amsterdam (the Netherlands). A computer laboratory, equipped with 30 microcomputers, has been available from 1988 onwards and a (compulsory) computer awareness course was introduced in the PESC curriculum. The

facility of a computer lab also enabled the introduction of computer assisted instruction in Mathematics and Science, especially for remedial purposes. The provision of remedial mathematics and science teaching through the computer is an advantage in the PESC setting, because other methods of remediation (e.g. by the lecturer or by peer tutoring) are not possible. This would require extra manpower, which is not available.

Students entering the PESC course come from different secondary schools, which causes great variation in knowledge level among students. Although all students passed their ordinary ('O') level exams, many do not really master the basic science and mathematical concepts. Though PESC is remedial in itself, and the same concepts are taught in PESC as already were taught in secondary school (with small extensions), still many students have difficulties with the subject matter. Extra individual remedial teaching via computers was expected to be a very helpful tool in this situation.

Smit and Wolff (1989) reported about the learning difficulties of PESC students in Mathematics (especially in Basic Algebra), caused by misconceptions which students have. Traditional teaching in PESC did improve the understanding of fundamental concepts in certain areas, but the formation of other concepts was still unsatisfactory. The suggestion made by Smit and Wolff that additional instruction with the computer may change this, resulted in the development of experimental software for Basic Algebra: the MASCART-Basic Algebra project. The MASCART-Basic Algebra project also serves as a pilot, to examine the possibilities of this type of software for PESC-Botswana, as well as for other, similar settings within developing countries. If this pilot would prove to be successful, the project could be extended to other subjects within PESC (Biology, Physics, Chemistry) and/or to other countries.

The main aim of the MASCART-Basic Algebra materials is providing remedial instruction aimed at improving the algebra knowledge and skills of students by overcoming misconceptions, which students might bring in from secondary school or from the regular PESC lessons. The software (MASCART materials) is meant to help students in remediating particular topics within Basic Algebra, by providing diagnostic exercises and specific feedback. Students can follow the MASCART course individually, without the help of the lecturer. The MASCART materials are being used complementary to the usual teaching program for Mathematics, and as such add two periods (2 x 45 minutes) per week extra to the teaching programme. As the MASCART project is the first educational computer application within the PESC Department, careful attention is given to the implementation of it on departmental, as well as teacher level.

The introduction of the computer in Botswana can be seen as an educational change. Such a change process can be conceived as consisting of three stages: initiation, implementation and institutionalization (Fullan, 1982). In the initiation stage, the decision of introducing computers in the PESC Department was taken. Implementation, being the process of putting the change into practice, is an important part of the process of educational change. Stable, routine implementation is one of the conditions for ultimate institutionalization of a change, that is for making the change an integral part of the functioning of the Department.

The evaluation of MASCART was initiated *after* its implementation was prepared and organized by the FUA and the PESC department. The evaluation focused on the following questions:
- Considering the conditions for successful implementation as mentioned in the literature (e.g. Fullan, 1982), has the implementation of computers in the PESC Department been such, that we may expect institutionalization ?
- Did the use of the MASCART software by students indeed result in knowledge gains?

Although misconceptions research is the base for the development of the MASCART materials, no further discussion will take place on the results in this light. Detailed analysis of the results has been done by Smit and Wolf and their reports discuss whether the misconceptions are changed since the introduction of MASCART (Smit, Oosterhout and Wolff, 1989a, 1989b).

In the next section, first a theoretical perspective and conceptual framework will be discussed. Then, the design and method for the study will be presented, while section four deals with the results.

2. PERSPECTIVE AND CONCEPTUAL FRAMEWORK

In this project, the evaluation strategy of Brinkerhoff, Brethower, Hlutchyi and Nowakowski (1983), consisting of seven steps, has been applied. In this strategy, the third step consists of the development of an evaluation plan, in which the procedures and sources for information collection are described. An educational evaluation plan needs an underlying framework, which is the basis for selecting information about the forces that influence student's achievement. A helpful framework can be derived from the three dimensional cube of Hammond (in Worthen & Sanders, 1987). The structure of this model is based on three sets of variables: population, behaviour and instruction (page 66). When dealing with the 'population', the different audiences playing a role in the project, can be included in the structure. 'Behaviour' can be seen as the goals and objectives for introducing MASCART; this category can be divided into the cognitive, affective and psychomotor domain. 'Instruction', being the process which will be evaluated, is in this study operationalised as those variables playing an important role in the implementation and institutionalization of the MASCART materials. These variables can be derived from theories on the implementation of educational change. These theories imply that change in practice occurs when certain elements (or factors) occur in combination.Fullan (1982), Fullan, Miles and Anderson (1988), Verspoor (1987) and Van den Akker, Keursten and Plomp (1989) distinguish several factors for the successful implementation of an innovation. These factors, as summarized by Janssen Reinen (1989), are given in Table1.

Insert Table1 about here

For ***Implementation***, three levels can be distinguished: the material level; the institutional level and the institution transcending level. At each level several factors play a role. At the **material level**, three factors are important. In order for implementation to succeed, implementors have to gain a *clear understanding* of what to do and what to change in order to put the innovation into practice. The problem of subjective and objective meaning of the change (that is, the possible discrepancy between the meaning of the receivers and the designers) belongs to this factor. The *complexity* of a change is dependent on the degree to which three dimensions are of relevance: the possible use of new or revised materials, the possible use of new teaching approaches, and the possible alteration of beliefs (Fullan, 1982). *Consensus about the change* is important because the prospects for successful implementation are greater when those, expected to carry out a change, agree on the need, on the appropriateness of the innovation selected, and on the priority of the change relative to other local concerns. Many changes fail to get implemented because the learning materials themselves are insufficiently developed, which indicates the importance of the *quality* of an innovation. Furthermore, the innovation should be *practical*. It should address students and teacher needs, it should fit well with the teacher's situation and it should include concrete how-to-do-it information.

At the **institutional level**, eight factors need to be taken into account. The *commitment* and actions of *(e.g. central office)* administrators are critical to the success of implementation efforts. Implementation is more likely to happen when there is clear, consistent communication and pressure from the administration, both initially and during the implementation. The *process of implementation and institutionalization* means that the people organizing and facilitating a change effort have to be able to put together a clear organization model and a set of procedures for achieving implementation and continuation of the change. *Professional development and assistance* are important for both the dissemination and implementation of educational implementations. Substantial changes in practice are unlikely to succeed without follow-up in-

service training and consultative assistance during implementation. The success of the implementation is also highly dependent on the creation of effective ways of getting information about the *implementation progress (monitoring) and problems*.** The crux of the matter is to get the right people talking together on a regular basis about implementation issues. Furthermore, effective implementation depends on the *principal* taking an active role in initiating and or responding to change efforts within the school. The principle must create a positive climate for change. The outcome of implementation is susce[illegible]ible to the influences of changes in the general organizational and social context, therefore the factor *environmental stability* must also be considered. *Mutual support* among the people working with the innovation as well as good communication are important, because everyone can learn from each others activities in the process of implementation. The motivation to use the change and the attitude towards the innovation of both students (users) and teachers are important, because they determine whether the innovation is actually going to be used. Therefore the last two categories: *user values and preferences* and *motivation and attitudes of teachers* are important as well.

At the **institution transcending level**, three factors are important. First of all, *community support*. Research indicates that implementation of most educational innovations proceeds without much community awareness and involvement. But when community members do take an active interest in the adoption and the implementation of particular innovations, their support for or against a change is likely to be a major factor in local decision making and commitment. *Environmental stability* deals with the economical and political background of the country in which the process of change takes place. *National context* covers the 'power' in a country, and, in this case, especially the policy of a Government towards the use of computers in education.

For ***institutionalization*** to occur, the same three levels as mentioned for implementation are important. At **material level** it is important that *the change has proved its worth* in the pilot phase of implementation. Otherwise, continuation of the change is not necessary.

At the **institutional level**, a *stable and routinely implementation* means a process of pilot use of the innovation without too much disturbances and with the implementation factors all taken into account. *Inbuiltness of the project* means that on the long term the innovation must not be seen as new any more. A *long term policy* must be formulated, which takes as starting point regular, self-evident and increased use of the innovation in the future. For computers, this policy could consist of the planning of new investments, the arrangement of maintenance, etc. The factor of *shared ownership and depersonalized patterns* is closely related to the inbuiltness of the project. Every participant in an organization, and not only the early adopters, should have the idea that working with the innovation is possible. Therefore a good *interaction* among all people of an institution is extremely important. Ultimately, an *active and motivated principal* is not only important during implementation, but also during this phase.

At **institution transcending level**, it must be clear that there is a continuing *necessity of the change*, which means that the change should contribute to the solution of an educational problem on that level. Only when that is the case, *support and planning* for institutionalization is possible. This means that general policies concerning the introduction of the innovation need to be developed and that financial support from the government must be considered.

All factors are included in the evaluation model and will be used to evaluate and analyse the implementation and institutionalization of computer use in the PESC Department. Combining the sets of variables of audiences, goals/objectives and change factors in one model (Figure 1), provides us with a conceptual framework for the evaluation.

Insert Figure 1 about here

Meta-analyses of educational computer use (e.g. Hasselbring, 1986) show that:
- the use of CAI improves student attitudes towards computer use in the learning situation;
- the positive effect on learning achievement occurs regardless of the type of CAI used, the type of computer system used or the age range of students;
- tutorial and drill modes seem to be more effective for low ability students than for middle or high ability students.

These results are based on research situated in more developed countries. This study investigates whether the same type of results also have validity in a less developed country.

Based on the above theoretical principles, the two general research questions have been operationalised into more concrete evaluation questions:

1.1 Are enough resources (budget, time, personnel) available for the total MASCART project and are sufficient preparations taken (on meso- as well as on micro level)?
1.2 Is the project sufficiently supported in the PESC department (on meso- as well as on micro level)?
1.3 Is the communication between relevant audiences adequate?
1.4 Are there any factors in the environment which influence process of implementation in a negative way?
1.5 Is the organisation (help available, other materials, problems) during the MASCART sessions adequate?
1.6 Are students positive about the new technology (computer) and the MASCART materials?
1.7 Is the MASCART software of good quality (considering presentation, instruction and mathematical content)?

2.1 Are there general gains in Basic Algebra knowledge for PESC students using MASCART, when compared to students who do not? Stated in other words: did the materials indeed proof their effect?
2.2 For which ability group of students (low, middle or high) is MASCART more effective?

3. RESEARCH DESIGN

3.1 Evaluation of the implementation of the MASCART materials

A case study design, using different instruments (observations, logbook- and program analysis, questionnaires and interviews), is the best research design to study the implementation of MASCART, the computer assisted remedial teaching (Yin,1988). The case study will show whether and why the implementation process has been successful or not. The assumption is that one can expect successful implementation, if during the implementation process the theories for implementing change (as operationalised in the preceding section) have been followed. If the case study indeed confirms this assumption, this study then replicates the conclusions of Verspoor (1987), and contributes in this way to the validity of theories on educational change in the context of less developed countries. Yin (1988) speaks in this context of replication logic. However, if implementation of MASCART will not be successful, then our theoretical assumption is apparently not the right one. This which will force us to reformulate the limits of validity.

Information sources

To answer the questions concerning the success of the implementation, data were collected by means of interviews, questionnaires and observation from Mathematics lecturers, other PESC staff, software developers, Basic Science Program Unit of the Free University, the computer lab assistant and the students.

The interviews and the questionnaire are developed on base of the evaluation questions. In order to collect the relevant information from students, while using computers, an observation instrument is used. The observation scheme was developed based on the results of an earlier pilot test of the MASCART materials, the classroom observation scheme of Harmon (1980) and a first week of non-systematic observation of all students following MASCART; the observation scheme was piloted in the second week. The main observation categories are:

- starting procedure;
- during the program: asking help, use of scrap paper, guessing, disturbances;
- ending procedure.

Furthermore, the computer lab assistant kept a logbook in which information was recorded, like assistance given to the students, technical problems that arose, influencing environmental factors etc. This logbook has been developed based on the results of the first week's observation of the assistant.

3.2 Evaluation of the effects of MASCART

In order to investigate the effects of MASCART, an experimental design has been developed. The following consideration had to be taken into account. The establishment of a control group of students, which would not receive any remediation at all, was morally not justifiable. This control group would be deprived of the chance of possibly getting better results, which they really need for getting a good recommendation after PESC. It was therefore decided that the control group should be able to work with MASCART after the experimental period, but at a time which was before the PESC examination.

Test design

A test-design has been set up, using the notation of Campbell and Stanley (1963). This design is depicted in Figure 2.

Insert Figure 2 about here

The total group of 260 PESC students (40 students left during the course) has been pre-tested in February 1989 after PESC-unit 1 (O1), using a 40-item multiple choice test on Basic Algebra (KR = 0.80). A normal PESC unit consists of lectures, practicals, tutorials, assignments and weekly achievement tests. Based on the results of this pre-test, the students have been matched (M) into equivalent experimental and control groups. The matching took place within the different PESC groups in order to keep other conditions (like kind of lectures, practicals and tutorials) as identical as possible. During Unit 2 of PESC, the experimental group received extra remedial teaching, using the MASCART materials that cover unit 1 (treatment X). This meant spending an extra two periods (2 x 45 minutes) per week on Basic Algebra. The control group only received the regular teaching of Unit 2 consisting of 8 periods of lectures, practicals and tutorials. A tutorial means time for students to ask questions about topics discussed that week. After Unit 2, the same Basic Algebra test (using a different sequence of questions) has been administered as post-test (O2, KR = 0.80). Afterwards, the second group received the treatment X. It is possible to measure the overall effect of cognitive knowledge gains by comparing the test results of both experimental group and control group on pre- and post-test (O1 and O2). Concerning the differential knowledge gains, two expectations exist:

- findings of e.g. Hasselbring (1986) indicate more effect of CAI for low ability students than for middle of high ability students;
- PESC lecturers, based on their teaching experience, expect that the middle ability group would gain most from MASCART.

To test these expectations, the total group of students has been divided into different ability groups. This has been done in two different ways, which will be explained later in 4.2.2 and 4.2.3.

Instruments

The Basic Algebra Test (BAT) used in this study, is not representative for the complete PESC content, but was developed to cover those parts with which students have learning difficulties (according to the experience of the lecturers). Pre-piloting of the test took place in June 1988. The coefficient alpha - all items proved to be .74, the Spearman-Brown coefficient was .72

4. RESULTS

In this section, the results of the research concerning the two questions will be presented. First the process of implementation will be considered; then the knowledge gains of students will be handled. The answers to both questions provide the necessary information to express some expectations concerning the further institutionalization of the MASCART project in the future.

4.1 The implementation process

The factors that may influence the process of implementation, as stated in Table 1 will be discussed below. Each of the factors will be given a score, in order to visualise the success of this factor. A (-) means that this factor is not taken into account during the process of implementation, while a (+) indicates that the factor is fulfilled. If no such judgement can be given, or if the factor is not applicable, the score (0) is given to the factor.

4.4.1 Characteristics of the materials

Considering the characteristics of the materials, that are important during the process of implementation, four different aspects can be distinguished.

Clarity and complexity (+)
In this project, developers, PESC Department, project supervisor and teachers appear to be well informed and know what is expected from them in the project. In the PESC setting, the innovation is complex to some extent because it concerns the introduction of an (almost) unknown technology. At the other hand, the innovation does not require a re-arrangement of the total organization of PESC or the subjects, in particular because MASCART is used in a remedial mode, extra and above the normal PESC classes. MASCART asks some extra time from the time schedule but the other subjects are not really affected by the change. Furthermore, the overall instruction strategies of the lecturers do not require any changes. This makes the change as a not too complex one and therefore easier to accept.

Consensus/conflict about the change (0)
From earlier project documents one cannot determine whether there is a real need within PESC for the introduction of a remedial, computer assisted course. Project staff and representatives of the University of Botswana and the Free University do agree that the MASCART project is appropriate in this setting.

Quality (and practicality) of the change (+)
External and internal sources judged that the mathematical content of MASCART is generally good (although minor revisions still can be made). The instructions in the program are clear and the use of a limited number of keys is consequently dealt with. The program is mainly computer controlled. This was considered to be the best option for this specific target group, which is not used to control their own learning process. The feedback is designed very carefully and reacts on the specific mistake made by the student. The presentation style is used consequently. The question whether the MASCART materials indeed correct misconceptions is answered by Smit, Oosterhout and Wolff (1989a, 1989b).

The opinions of the students about the quality of the software are collected through a questionnaire. Most students very much like to work with MASCART. In their opinion, the instructions are very clear and the feedback was considered to be very useful. Observations during the MASCART session showed that the students worked with much concentration. In summary, it can be concluded that the MASCART materials are of good quality.

Relevance (+)
The PESC lecturers do not have extra time needed to assist individual students with their problems. This situation is not likely to change in the near future because the number of students in PESC will keep growing in the coming years. Although MASCART was not initiated from a perceived need of the PESC Department, the staff judged it as highly relevant.

4.1.2 Institutional level

On institutional level, several factors are important to take into account during the process of implementation (Table 1). The implementation of MASCART was not organized on the basis of these factors. Afterwards, the goodness of fit of these factors was reconstructed.

Central office direction, commitment and support (+)

For this factor two institutions need to be taken into account in this project, the Free University Amsterdam and the Department at the University of Botswana. Money and materials came for a great deal from the Free University (and international donor organisations). This university provided a great deal of expertise through the development of the courseware and the provision of support, where necessary. Time, operationalized in concrete implementation activities, was contributed by the Mathematics and Computer section of PESC, in which the Head of Department is a leading figure (see a separate factor below).

Professional development assistance and participation (0/-)

Because MASCART is supposed to be lecturer independent, there is no immediate necessity to train PESC lecturers for this specific innovation. Yet, it would be wise to have several people in the PESC Department who would have some technical knowledge of computers and who are familiar with TAIGA, the authoring system used to develop MASCART. In the long term, it is not wise to rely for technical problems completely on the experience of one computer expert within the Mathematics section or on a computer company,. Also, the courseware development expertise of the Free University must not be the only source for educational software.

Implementation monitoring and problem solving (-)

In order to monitor the implementation, there should be a detailed plan of implementation and someone should be available to monitor the process and to solve problems during the process of implementation. In the PESC setting, this factor is not fulfilled. During this pilot phase, monitoring took place via the two available researchers. Problem solving is, next to the limited help of the computer company, done by one lecturer who has computer experience. He has to do this next to his normal teaching job. If the computer lab assistant would be better qualified, she could do this job. In the case of PESC, the assistant was not trained to solve technical problems and, not being a Mathematician, she could not assist students in difficult mathematical problems either.

Principal's leadership (+)

As already stated above, the Head of Department is a leading figure in the project. He is very enthusiastic about the project and recognizes also other possibilities of introducing the new technology in the department. Although not directly involved in the implementation of the materials, he wants to be kept informed about the activities within the project.

Environmental stability (+)

The stability of the environment can be considered in two different ways. The PESC Department as the environment of MASCART, is a stable, motivating environment for the introduction of an innovation. On the other hand we have the computer lab, as the physical environment of the computers. When working with this technology (especially in the context of a less developed country), it is important to place the computers in the right environment. The newly built computer lab is dust free (dust covers are available for every computer) and air-conditioned and can therefore considered to be an excellent environment for the computers. The only problem in the beginning was that the air-conditioners did not work; however the high temperature did not have a noticeable effect on the computers. The other disturbing factor of the environment in this pilot phase, noise, is also considered to be a temporary factor with no disturbing influence in the long run.

Networking (+)

Communication among the different participants took place in a very informal way. Within the project itself, communication took place on an equality base of both counterparts (Free University Amsterdam and University of Botswana) in the project, because there is a regular

correspondence between software developers and the computer expert of PESC. The mutual support among the colleagues of the department is good. However, because only one person could be considered as 'computer expert', he alone was doing most of the activities.

User values and preferences (+)
From the observations, it could be concluded that students were very eager to learn and are highly enthusiastic. The student questionnaire also pointed at favourable opinions of students about the use of the MASCART software.

Motivation and attitudes of teachers (0/+)
Because the MASCART materials are meant to be lecturer independent and the lecturers were not directly involved in the execution of the experiment, this factor was not of very much importance during this first experience with computers in PESC courses. However, as already mentioned, staff and representatives are very motivated and have a positive attitude towards the project.

4.1.3 Institution transcending level

The factors mentioned in Table1 as being important on this level (community support, environmental stability and national context) are not applicable in this case because of the specific position of the project. The project started through cooperation between PESC and the Free University Amsterdam and is therefore relatively independent from national policy. Aims and values of the government do not have an influence on the project, although it is interesting to see that the project fits within the plans of the government to introduce computers in the educational system. Politicians in Botswana are nowadays very positive about the use of computers in education as this contributes to a better job qualification. At present, there is a great demand for people who have experience with computers.

4.1.4 Synthesis

The presented results of the process of implementation make clear that in general the process of implementation has been carried out without many disturbing factors. Most factors have indeed been fulfilled, but concerning a few factors, improvements are possible. The conclusion can be that the implementation of MASCART within the PESC setting has indeed been rather successful.

4.2 Knowledge gains

4.2.1 General knowledge gains
The hypothesis whether students using the MASCART materials (experimental group) perform better on the Basic Algebra Test (post-test), than students who did not use the materials (control group), was tested one-sided (= 0.05, Table 2).

Insert Table 2 about here

These results indicate that students in the experimental group indeed performed significantly better. Their knowledge and skills in basic algebra have indeed improved more than knowledge and skills from students in the control group. Whether this improvement is caused by the quality of the MASCART materials or by the increased time on task (students of the experimental group receive about 2 x 45 minutes of remedial teaching per week extra) cannot be determined from these results. This dilemma will be discussed in more detail in section 4.2.3. On the other hand, if MASCART would not exist, no other form of remediation could have been possible because lecturers do not have time for this kind of activities.

4.2.2 Effects on ability group

The second question is whether the MASCART materials have different effects for the different ability groups (low, middle and high). This question has been examined by using two different methods. The second method will be explained in section 4.2.3. For the first method, the total group of students are divided into four quartiles; the low ability group consisting of the 25% with the lowest score on the pre-test, the middle ability group of the next 50% of the students and the high ability group of the top 25%. The MASCART materials have been developed for the low- and middle ability group especially, but the lecturers of PESC believe that the main effects will be found in the middle ability group. They expected that the entrance level of the materials may be a little too high for the low achievers. The null hypothesis to be tested is that all three ability groups will equally gain from MASCART.

Figure 3 shows the mean scores on the pre- and post test for both experimental- and control group at the three ability levels. The two lines in the middle of the figure represent the results for both groups on the pre-test. The two lines are about the same which was to be expected because the matching procedure was based on the results of this test. The upper two lines represent the results on the post-test. The general effect of MASCART is shown, since the scores of the experimental group are higher. It can be seen from the results of the control group that the regular instruction in PESC (about other topics than Basic Algebra) also improve the scores on the post test.

Insert Figure 3 about here

A regression analysis has been conducted to check whether the factor ability has indeed a significant effect. The results of this regression analysis are shown in Table 3. This Tableagain shows that there is indeed an effect caused by the experimental group. Also, the factor ability plays a role of significance. From these data it cannot be concluded which ability group benefited the most. Therefore, a more thorough analysis is needed.

Insert Table 3 about here

Table 4 shows the differential scores (post-test minus pre- test scores) for the experimental- and the control group of the three ability groups. The two middle regression lines in Figure 4 are based on these results. They indicate that the low ability group is benefiting relatively more than the middle or high ability group. The lowest line depicts the difference on the post test between the experimental and the control group. This line can be considered to be the 'netto effect' of MASCART.

Insert Table 4 about here

Insert Figure 4 about here

4.2.3 Better results due to more time on task or to quality of MASCART?

Next to the regular eight periods of instruction, students in the experimental group received two extra periods of remedial instruction per week, by working through the MASCART materials. The analysis applied so far does not allow us to determine whether the improved results of the experimental group is a result of just more time on task, or whether the quality of the MASCART materials contributed to the efficiency of the remedial activities. The approach of Chen (1990), in which he applies Markov chain analysis on repeated data on educational achievement of a certain group of students, may shed light on this question. Under the assumptions that (i) every student can reach a pre-defined mastery level if he spends enough time on the learning task, and (ii) the quality of the instruction given is stable , one can, by applying Markov chain analysis, calculate for each pre-defined (sub)group the expected average time to reach the pre-defined level of mastery. By applying this analysis to our experimental and to our control group, differences in expected time to reach mastery level might reveal differences between the quality of instruction in both conditions, and in this way help us to separate the possible two causes of the effect of the experimental conditions (that is more time on task, and the quality of the MASCART materials).
For this purpose, the students in the experimental and control group are divided in five ability categories (second method for ability grouping) based on their score on the pre-test (40 items). Table 5 depicts this ability distribution of the pre-test and the post-test for both the experimental and the control group.

Insert Table 5 about here

To apply Markov chain analysis (MCA) on the Basic Algebra Test (BAT), the data on the pre-test and post-test for both groups need to be presented in a transition matrix, indicating how students on a certain level on the pre-test score on the post-test. Table 6 contains the transition matrices for the experimental and the control group. The results of the MCA according to Chen (1990) are given in Table 7.

Insert Table 6 about here

Insert Table 7 about here

The interpretation is, that in the experimental group the subgroup of students who scored in the pre-test on level 2, needs an average of 1.19 TE (time units of the experimental group) to reach the defined mastery level (that is level 1; see Table 5). Similarly, in the control group the subgroup of students who are, for example, in the pre-test on level 3, needs an average of 2.27 TC (time units of the control group) to reach the defined mastery level (level 1). As the time on task in the experimental group (MASCART) is greater than in the control group, Table 7 also contains the expected times for the experimental subgroups calculated in the time units of the control group. The data show that for the subgroups in the experimental condition in all cases the expected average time to reach the desired mastery level (level 1, Table 5) is smaller than for the equivalent groups in the control condition.
Because of the stochastic nature of the phenomenon we are analyzing, we cannot conclude that the experimental condition is always better than the control condition, or that (after having corrected for the differences in time units between the experimental and the control group) the

better performance of all experimental (sub)groups is due to the quality of the MASCART materials. For this we have to test whether the expected average time (in both the non-corrected, as the corrected situation) for the experimental subgroups is shorter than for the control group.

Chen (1990) also developed a procedure for testing the null hypothesis that the expected time for both the experimental group and the control group come from the same population; that is that the difference between the expected times results from stochastic observations. To test this hypothesis, Chen applies the Pearson chi-square procedure. In this case, the contingency tables are 1*4 tables:

T(observed, experimental):	1.19 1.63 1.96 2.46
T(observed, control):	1.75 2.27 3.06 3.21
T(theoretically expected):	1.47 1.95 2.51 2.84

where the both T(observed) are the expected times for the subgroups in the experimental condition (not corrected, see Table 7) and the control condition, and the T(theoretically expected) is the mean value of the other two. The Pearson chi-square test statistic is 13.68, while the critical value is 9.49 (df=4; alpha 0.05). We can reject the null hypothesis, which means that the expected time for reaching the mastery level is significantly shorter in the experimental group than in the control group, in the case of not correcting for differences in the unit of time. This result is consistent with the preceding section, where we tested the differences in post-test scores between both groups.

Applying the test procedure on the corrected expected times (for the experimental group) , then the test statistic is 3.99 (df=4), which is not significant for alpha = 0.05.
In 4.2.2 we found that especially the weaker students profited from MASCART. We therefore applied the same test in an explorative way on only the levels 4, and 5 subgroups. The test statistic is 1.96 (df=1), which is not signifficant (alpha = 0.05).

4.2.4 Conclusion
In this section, the effects of the MASCART materials on student knowledge in Basic Algebra have been examined. A general improvement in basic algebra knowledge and skills could be measured. We could not proof that this improvement was caused by the quality of the MASCART materials; but the data show that the combination of increased time on task and the working with MASCART materials was effective.

One might argue that a cheaper way of remedial teaching might have been to give students an extra tutorial per week, instead of the MASCART sessions. However, when considering the rather low attendance of students during regular tutorials, it is doubtful whether the same effect could have been reached using this kind of remedial teaching. In the PESC situation, different kinds of remedial teaching are not relevant options, since mathematics staff does not have time to give extra tutorials. The MASCART materials have been designed especially to satisfy this need and are therefore lecturer independent. So, one might say that the computer assisted MASCART materials have proved to be a successful means to realize remedial instruction, where at present no other possibilities for remedial instruction are easily possible.

Another effect of the MASCART materials was the effect on student motivation. The questionnaire about the MASCART materials indicated that students liked to work with MASCART very much, because they could work individually and at their own pace. Whether this positive effect on students' motivation will last when the 'novelty' effect is gone, has yet to be studied in this situation. It can be concluded that indications exist that this factor for lasting success (effectiveness of the materials) is indeed fulfilled in the MASCART situation, although some improvements in the materials can be made.

4.3 Institutionalization

Because the MASCART project is not yet in its institutionalization phase, a number of factors of Table 1 can not yet be discussed properly at this moment. However, because the implementation process has already taken place and because some insight in the effects of the use of the materials is already gained, some expectations concerning the future continuation of the project can be made. But first, the institutionalization factors will be discussed.

4.3.1 Material level (+)

At the material level, it was checked whether the implemented materials have indeed proved their effectiveness. It appeared that the students indeed gained from the MASCART sessions. Therefore this factor can be considered to be fulfilled.

4.3.2 Institutional level

On institutional level (PESC level), there are six factors that are important for lasting success.

Stable, routinized implementation (0/+)
From the information discussed in section 4.1.1, it has become clear that the implementation took place in a relatively stable situation. Because the MASCART project (in combination with the Computer Awareness Course) was the first real innovation with which the PESC Department had to deal, the process of implementation can not be called routinized yet. However, no major problems occurred during the process of implementation.

Inbuiltness of the project (0)
It is too early to conclude that the MASCART-Basic Algebra is already 'built in' in the PESC situation. Although there are concrete plans to continue with the Basic Algebra materials, and to extend the project to other areas within Mathematics and to other subjects within PESC, the project cannot be labelled as 'invisible' or 'widely used' yet. A positive aspect of the MASCART project is that, once the materials are piloted and revised, they belong to the PESC Department and this department has full responsibility for the use of the materials. PESC is no longer dependent on external help concerning MASCART, which fosters the factor of inbuiltness of the project in the department.

Long term policy (0)
Just as with the above factor, it must be concluded that there is no explicit future policy plan for the MASCART project at the moment. The larger PRESS project, of which the MASCART project is a part, is planned to run until 1991. The plans for MASCART till that time are stated in the plan for the total PRESS project. What is going to happen after the project period has expired is not known yet.

Shared ownership and depersonalized patterns (0)
For the continuation of the MASCART project in the future, the factor of 'shared ownership' plays an important role. Although all staff members are eager to learn about the usefulness of the materials and are very interested, in practice the work during the pilot phase has been done by the computer expert of the Mathematics and Computer section only. This in fact leads to a 'single ownership', which is not an optimal condition for continuation of the project.

Interaction (+)
Communication channels have been quite good during the process of development and implementation of the MASCART materials. Still, emphasize must be put on the importance of communication and interaction, because the literature showed that a project can only succeed when everyone is continually informed about the activities going on (Janssen Reinen, 1989). Especially when the MASCART project is going to be incorporated in the department, interaction among staff members should be planned in order to keep colleagues informed about the activities of the different staff members.

Leadership (+)
As already stated earlier, the role of the Head of Department is an important one during the process of implementation. But his role does not stop after the phase of implementation. The process of continuation requires a person with a continuing positive attitude and willingness to support, in order to make the ultimate innovation successful. In the situation of PESC, such a leading figure is present and therefore, this factor can be considered to be fulfilled.

4.3.3 Institutional transcending level
At the institution transcending level, two factors play a role: the necessity of the change and the support and planning for the future of the MASCART project. For this project, the transcending level consists of the University of Botswana and the broader national context (the Ministry of Education).

Necessity (0)
No clear information is available about the future necessity of the project at the institution transcending level. Based on Botswana's sixth National Development Plan (Ministry of Finance and Development Planning, 1985), it can be expected that the PESC intake of students is continuing to grow. This means a growing number of students with differing backgrounds. In such a heterogeneous situation, it can be expected that MASCART and/or other computer assisted instruction (CAI) applications (see Pilon, 1989) can play an important role. Students who lack basic knowledge of certain topics can work individually on those problem areas, without further assistance of a lecturer. Thus, the conclusion can be that the need for MASCART (and CAI in general at University level) will probably continue to be present in the future.

It is more difficult to say something about the future of MASCART at national level. It can be expected that the need for computers in the education of Botswana will continue to exist, especially when the plans of the Ministry of Education to introduce five computers per senior secondary school are considered (see Janssen Reinen and Pilon, 1989). It is not known to what extent MASCART fits into these plans.

Support and planning (0)
Again, no information is available about future support or planning by the University of Botswana and the Ministry of Education concerning MASCART. Although it is known that the University is very interested in the introduction of computers in education, no definite plans about future support of the MASCART project or other CAI projects exist. This also applies for the Ministry of Education of Botswana. Although their policy is aimed at introducing computers in education, there are no plans concerning computer assisted instruction projects such as the MASCART project.

The conclusion can be that, although there certainly is a positive attitude concerning the computer and its application in education, there are no concrete plans at this level, which point at a future implementation of MASCART in similar projects in Botswana.

4.3.4 Synthesis

As mentioned before, for some factors which are important for continuation of the project, it is too early to be fulfilled. But we also concluded, that some important implementation factors are not yet fully taken into account. Especially the fact that MASCART is still depending very much on the efforts of one person within PESC, the computer expert of the Mathematics section, might be a too weak basis for continuation of the project. If MASCART is really to be 'built in' in the PESC Department in a depersonalised way, more people should be made responsible, so that the project is not longer dependent on one person.

5. CONCLUSIONS AND DISCUSSION

In this paper, factors which are considered to be important for implementation and institutionalization of educational changes, were investigated in a setting in a less developed country. It appeared that many of the factors mentioned in section 2 (Table 1), were indeed fulfilled in the specific setting of PESC-Botswana, leading to a rather smooth implementation of the MASCART materials. Concerning the process of institutionalization, there were still some factors undetermined, but no contra-indications were yet found. Based on this case study we therefore conclude, that for the time being we have no reasons to doubt the validity of our theoretical assumptions, spelled out in section 2. We can also conclude that, if the people involved in the project are going to take the conclusions of this analysis into account, then it can be expected that MASCART will become an integral part of PESC, after the project period will expire. The ultimate answer to this can only be given after an evaluation some years from now.

REFERENCES

Akker, J.J.H. van den, Keursten, P., & Plomp, Tj. (1989). *The integration of computer use in education* (in press).

Brinkerhoff, R.D., Brethower, D.M., Hlutchyj, T., & Nowakowski, J.R. (1983). *Program evaluation. A practitioners guide for trainers and educators.* Hingham, MA: Kluwer Nijhof Publishing.

Campbell, D.T, & Stanley, JC. (1963). *Experimental and quasi-experimental designs for research.* Boston: Houghton Mifflin.

Chen, Yu Kun, & Plomp, Tj. (1990) Markov chain analysis of the effectiveness of education programs. Enschede (the Netherlands): University of Twente, Department of Education.

Fullan, M. (1982). *The meaning of educational change.* New York: Teacher College Press, Columbia University.

Fullan , M., Miles, M.B., & Anderson, S.E. (1988). *Strategies for implementing microcomputers in schools: the Ontario case.* Ontarion: Ministry of Education, Queen's printer.

Harmon, D.J. (1980). *Kanawah county schools/West Virginia University teacher corps project.* (ERIC Document Reproduction Service No. ED 209 266).

Hasselbring, T.S. (1986) Research on the effectiveness of computer-based instruction: a review. *International review of education, 32*(3), pp.313-24.

Janssen Reinen, IA.M. (1989). *The implementation of the computer in the education of a less developed country*. Enschede: University of Twente, Department of Education.

Smit, C.P., & Wolff, P.F.J. (1989).*Conceptual difficulties in Basic Algebra. MASCART Report 1*. Amsterdam: Free University.

Smit, C.P, Oosterhout, M., & Wolff, P.F.J. (1989a). *A Basic Algebra Course: learning difficulties and experimental courseware. MASCART report 3*. Amsterdam: Free University.

Smit, C.P, Oosterhout, M., & Wolff, P.F.J. (1989b). *The effectiveness of computer assisted instruction. MASCART report 4*. Amsterdam: Free University.

Ministry of Finance and Developemnt Planning (1985). *Republic of Botswana. National developemnt plan 1985-91.* Gaborone: Government Printer.

Pilon, J. (1989). *The use of computers for remedial teaching in mathematics and science education*. Enschede: University of Twente, Department of Education.

Verspoor, A.M (1987). *Pathways to change: improving the quality of education in developing countries*. Washington, D.C. the World Bank.

Yin, R.K. (1984). *Case study research: design and methods*. Beverly Hills: Sage Publications.

TABLES AND FIGURES

Table 1: Factors influencing implementation and institutionalization
Source: Janssen Reinen, 1989

IMPLEMENTATION	INSTITUTIONALIZATION
1. Material level - clarity and complexity - consensus/conflict about the change - quality (and practicality) of the change	1. Material level - materials have proved their effectiveness
2. Institutional level - central office direction, commitment and support - process for implementation and institutionalization - professional development and assistance (teachers) - professional development and assistance (others) - implementation monitoring and problem solving - principal's leadership - environmental stability - mutual support (internal) - user values and preferences - motivation and attitudes of teachers	2. Institutional level - stable, routinezed implementation - inbuiltness of the project: - widespread use - invisibility - rise in legitimacy - organisational space - continued assistance - long term policy (including maintenance plan) - shared ownership and depersonalized patterns - interaction (communication) - leadership
3. Institution transcending level - community support - environmental stability - national context	3. Institution transcending level - necessity of the change - support and planning ('managed change')

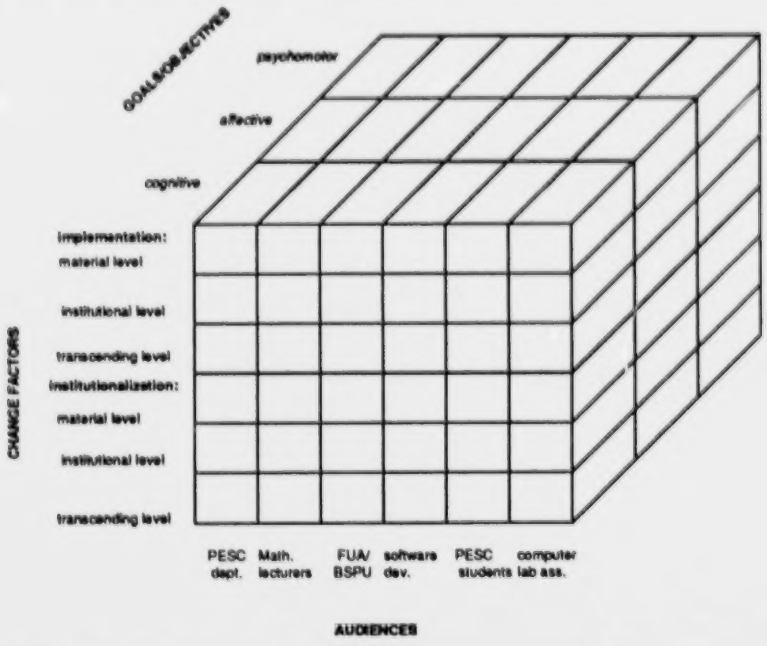

Figure 1: Evaluation framework

experimental group	O1	M	X	O2
control group	O1	M		O2

Figure 2: Test design

Table 2: Mean scores and standard deviations on pre- and post-test and t-test results

		Mean scores +/- s.d.	
Group	N	pre-test	post-test
exp.	130	26.06 +/- 5.89	32.98 +/- 4.80 *
contr.	130	26.11 +/- 5.89	30.96 +/- 5.44 *

* significant difference with P< 0.05

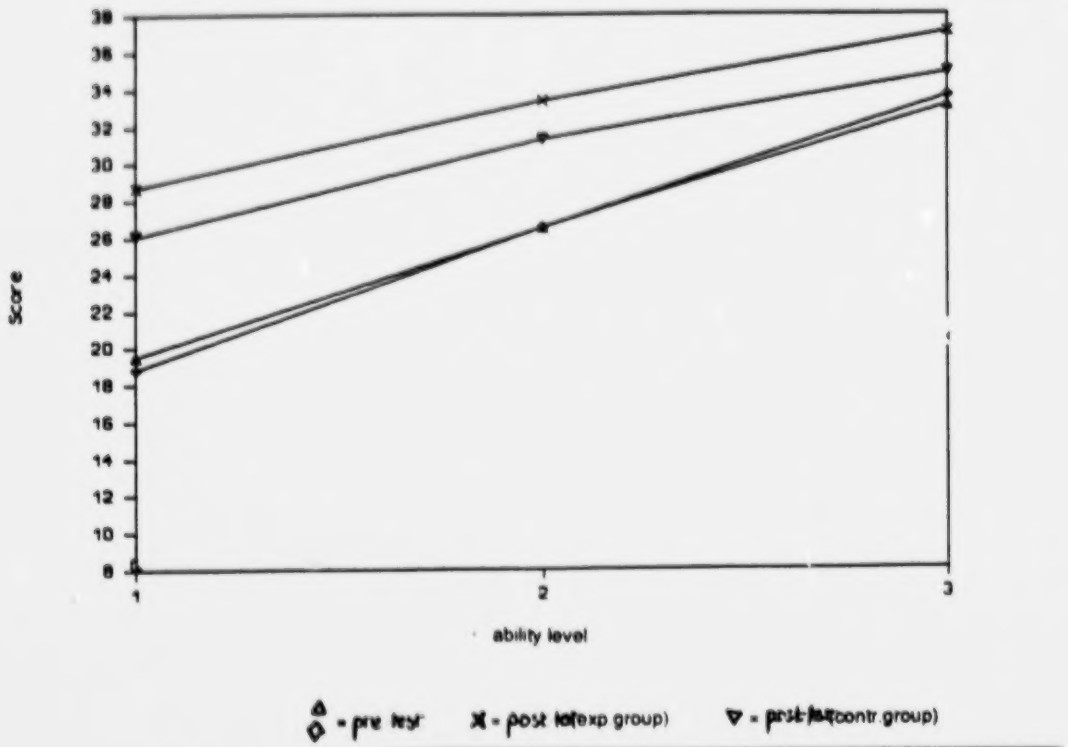

Figure 3: Scores on pre- and post-test per ability group

Table 3: Results of the regression analysis for experimental group and ability

Source	Sum of squares	Df	mean square	F-ratio	P
Group	212.96	1	212.96	16.56	0.00
Ability	1094.32	2	547.16	42.55	0.00
Group*ability	0.84	2	0.42	0.03	0.97
error	2623.13	204	12.86		

Table 4: Differential scores (pre-test minus post-test) per ability group

	Mean differential score +/ stand.dev		
	ability group:		
	low	middle	high
group: exp.	n=36 9.86+/-4.06	n=63 6.95+/-3.07	n=31 3.42 +/ 2.42
contr.	n=38 7.23 +/ 4.93	n=61 4.53+/-4.07	n=31 1.38 +/ 2.51

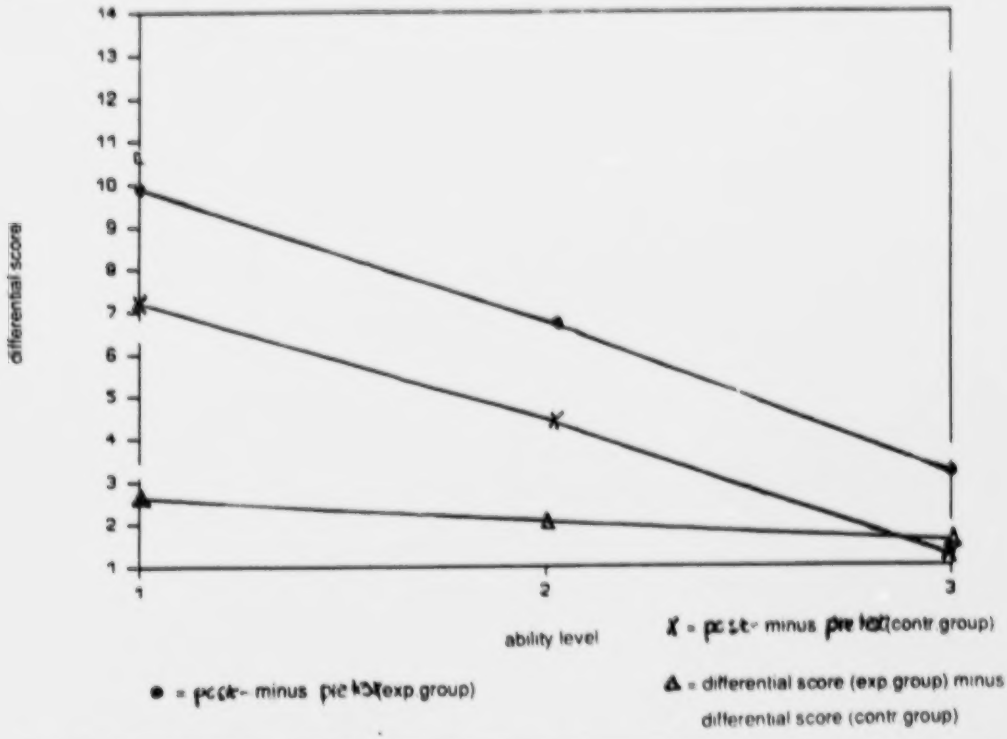
differential score
ability level
● = post- minus pre test (exp group)
X = post- minus pre test (contr group)
Δ = differential score (exp group) minus differential score (contr group)

Figure 4: Differential scores per ability group

Table 5: Distribution of students in the experimental and control group

ability level	nr. of items correct on BAT	Number of students			
		exper. group		control group	
		pre-test	post-test	pre-test	post-test
1	33-40	20	78	20	57
2	28-32	43	38	41	44
3	23-27	35	3	35	18
4	19-22	16	7	22	7
5	<=18	13	1	11	3

Table 6: Pre-test/post-test transition

	Pretest level						
Experimental group	1:	20	19	1	0	0	0
	2:	43	36	7	0	0	0
	3:	35	17	17	1	0	0
	4:	16	5	8	1	2	0
	5:	13	1	5	1	5	1
	Posttest level		78	38	3	7	1
			1	2	3	4	5

	Pretest level						
Control group	1:	20	17	3	0	0	0
	2:	41	24	14	3	0	0
	3:	35	13	15	4	2	1
	4:	22	2	10	8	2	0
	5:	11	1	2	3	3	2
	Posttest level		57	44	18	7	3
			1	2	3	4	5

Table 7: Expected time to reach mastery level

Subgroup level	Expected time * to reach level 1	
	experimental group	control group
2	1.19 (1.42)**	1.75
3	1.63 (1.96)	2.27
4	1.96 (2.35)	3.06
5	2.46 (2.95)	3.21

* the unit for expected time is the amount of instruction between pre-test and post-test; for the control group 4 weeks of 4x2 lesson periods (Tc); for the experimental group Te is Tc plus 4 weeks of 2 periods per week MASCART instruction; so Te = 1.2x Tc.

** The expected time for the experimental group is Tc units (multiplication factor 1.2).